

WHAT IS CLAIMED IS:

1. A method for rebalancing the disks among the network storages in a virtualized network storage system including the multiple network storage devices, a virtualizing device, and a network 5 for connecting them, wherein said multiple network storage devices virtually look to clients as if the network storage devices were a single network storage device owing to the functions of said virtualizing device, the method comprising:

a rebalancing process which comprises the steps of:

10 moving one or more files stored in a first network storage device of said multiple network storage devices to a second network storage device of said multiple network storage devices (disk rebalancing step); and

examining the free disk spaces in the individual network 15 storage devices to judge whether to continue the processing based on the maximum value and minimum value of the free disk spaces and a first threshold and, if the processing should be continued, going back to said disk rebalancing step and if the processing is not to be continued, terminating the processing 20 (termination judging step); and

a monitoring process which comprises the steps of:

periodically examining the free disk space in each of 25 said multiple network storage devices, and judging based on the maximum value and minimum value of the free disk spaces and a second threshold whether to start the rebalancing (first

start of rebalancing determining step); and

if it is judged in the first start determining step that rebalancing should be started, starting the rebalancing (rebalancing starting step).

5 2. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein in said termination judging step in said rebalancing, if the difference between the maximum value and minimum value of the free disk spaces is equal to or greater
10 than the first threshold, the operation goes back to the disk rebalancing step to continue the processing and if not, the processing is terminated.

3. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein in the start of rebalancing determining step in said monitoring process, if the difference between the maximum value and minimum value of the free disk spaces is equal to or greater than the second threshold, it is determined that rebalancing should be started.

20 4. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein in addition to said first start of rebalancing determining step, said monitoring process comprises the step of: if the free disk space in at least one of said multiple
25 network storage devices is less than a third threshold,

- determining start of the rebalancing is determined (second start of rebalancing determining step), and
- in said rebalancing starting step, if start of rebalancing is determined both in said first start of rebalancing determining step and in said second rebalancing determining step, said rebalancing is started.
5. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein in addition to said first start of rebalancing determining step, said monitoring step comprises the step of: if the free disk spaces in all the network storage devices are equal to or greater than a fourth threshold, determining start of rebalancing (third start of rebalancing determining step); and
- 10 15 in said rebalancing starting step, if start of rebalancing is determined both in the first start of rebalancing determining step and in the third start of rebalancing determining step, the rebalancing is started.
6. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein in addition to said first start of rebalancing determining step, said monitoring process comprises the step of: if the frequency of accesses from clients to said virtualized network storage system is less than a fifth threshold,
- 20 25 determining start of rebalancing (fourth start of rebalancing

determining step);

in said rebalancing starting step, if start of rebalancing is determined both in said first start of rebalancing determining step and in the fourth start of rebalancing determining step,

5 the rebalancing is started; and

in the termination judging step in said rebalancing, the free disk space in each of said multiple network storage devices is examined and if the difference between the maximum value and minimum value of the free disk spaces is equal to or greater

10 than said first threshold and further the frequency of accesses from clients to said virtualized network storage system is less than the fifth threshold, the operation goes back to said disk rebalancing step in said rebalancing, and

if the difference is less than the first threshold or the
15 frequency of the accesses is equal to or greater than the fifth threshold, the processing is terminated.

7. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein said virtualizing device has a free disk
20 space table and the free disk space table holds the identifier of and the free disk space in each of said multiple network storage devices.

8. The method for rebalancing the disks among the network storages in a virtualized network storage system, according
25 to Claim 1, wherein said disk rebalancing step in said

rebalancing comprises of the steps of:

selecting a network storage device having the smallest free disk space as the source network storage device and a network storage device having the largest free disk space as the destination network storage device (network storage device selecting step);

selecting one or more files stored in the source network storage device selected in the network storage device selecting step (file selecting step); and

moving the files selected in the file selecting step from the source network storage device to the destination network storage device (file moving step).

9. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 8, wherein said disk rebalancing step in said rebalancing further comprises the step of storing the history of rebalancing, and in said network storage device selecting step, network storage devices selected as the source network storage device in the past are excluded from objects to be selected as the destination network storage device and network storage devices selected as the destination network storage device in the past are excluded from objects to be selected as the source network storage device.

10. The method for rebalancing the disks among the network storages in a virtualized network storage system, according

to Claim 8, wherein said file selecting step in said disk rebalancing step in said rebalancing further comprises the step of comparing a first estimated value which is equal to the sum of the free disk space in the source network storage device 5 and the size of files to be moved with a second estimated value which is equal to the difference between the free disk space in the destination network storage device and the size of files to be moved, and if the magnitude relation between the first estimated value and the second estimated value is inverted with 10 respect to the magnitude relation between the free disk space in the source network storage device and the free disk space in the destination network storage device, files to be moved are reselected.

11. The method for rebalancing the disks among the network 15 storages in a virtualized network storage system, according to Claim 8, wherein

 said virtualizing device has file location information which is a record of the correlation between files and network storage devices to which the files belong,

20 said file moving step comprises the steps of: copying files stored in said source network storage device to said destination network storage device (copying step), deleting the files from said source network storage device, and updating said file location information, and

25 if a user sends a write access request into a file while the

file is being moved, the file moving step is aborted, the file to be moved is deleted from the destination network storage, and the file selecting step is carried out again.

12. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein

said virtualizing device has file location information which is a record of the correlation between files and network storage devices which stores the files,

10 said file moving step comprises the steps of: copying file to be moved in said source network storage device to said destination network storage device (copying step), deleting said files to be moved from said source network storage device, and updating said file location information, and

15 the virtualizing device comprises a means for, if a user sends a write access request into said file while the file moving step is being carried out, abandoning the access request.

13. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 1, wherein in response to an instruction to start from an administrator, said rebalancing is started and in response to an instruction to abort from the administrator, said rebalancing is aborted.

14. The method for rebalancing the disks among the network storages in a virtualized network storage system, according

to Claim 1, wherein said monitoring process is repeatedly carried out at preset time intervals.

15. A method for rebalancing the disks among the network storages in a virtualized network storage system including the multiple 5 network storage devices, a virtualizing device, and a network for connecting them, wherein said multiple network storage devices virtually look to clients as if the storage devices were a single network storage device owing to the functions of said virtualizing device, the method comprising:

10 a rebalancing which comprises the steps of:

migrating a file group comprising one or more files stored in a first network storage device of said multiple network storage devices to a second network storage device of said multiple network storage devices (disk rebalancing step) and

15 examining the free disk spaces in the individual network storage, judging based on the maximum value and minimum value of the free disk spaces and a first threshold whether to continue the processing, and if the processing is to be continued, going back to said disk rebalancing step and if the processing is 20 not to be continued, terminating the processing (termination judging step); and

a monitoring process which comprises the steps of:

periodically examining the free disk space in each of said multiple network storage devices and judging whether to 25 start the rebalancing based on the maximum value and minimum

value of the free disk spaces and a second threshold (first start of rebalancing determining step) and

starting said rebalancing if it is judged in the first start judging step that rebalancing should be started
5 (rebalancing starting step).

16. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 15, wherein

said disk rebalancing step in said rebalancing comprises the
10 steps of:

selecting a network storage device having the smallest free disk space as the source network storage device and a network storage device having the largest free disk space as the destination network storage device (network storage device
15 selecting step);

selecting one or more of file groups stored in the source network storage device selected in the network storage device selecting step (file group selecting step); and

migrating the target file groups selected in the file group
20 selecting step from the source network storage device to the destination network storage device (file group migrating step).

17. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 16, wherein

25 said virtualizing device records the relation between file

groups and network storage devices to which the file groups belong,

 said file group migrating step comprises the steps of: copying all the files belonging to the target file group for migration 5 in said source network storage device to said destination network storage device (copying step), deleting all the files belonging to the target file group for migration from said source network storage device, and updating said group location information, and

10 if a user sends a write access request into at least one file belonging to the target file group for migration while the file is being migrated, the file group migrating step is aborted, all the files belonging to the target file group for migration are deleted from the destination network storage, and said file 15 group selecting step is carried out again.

18. The method for rebalancing the disks among the network storages in a virtualized network storage system, according to Claim 16, wherein

 said virtualizing device records the relation between file 20 groups and network storage devices to which the file groups belong as group location information,

 said file group migrating step comprises the steps of: copying all the files belonging to the target file group for migration in said source network storage device to said destination network 25 storage device (copying step), deleting all the files belonging

to the target file group for migration from said source network storage device, and updating said group location information, and

5 said virtualizing device comprises a means for, if a user sends a write access request into at least one file belonging to the target file group for migration while the file group migrating step is being carried out, abandoning the access request.

19. A virtualized network storage system including multiple
10 network storage devices, a virtualizing device, and a network between them, wherein said multiple network storage devices virtually look to clients as if the storage devices were a single network storage device owing to said virtualizing device, the system, wherein

15 said virtualizing device comprises a holding means for holding file location information indicating the correlation between files and network storage devices which stores the files, a virtualizing means, and a disk rebalancing means, and the disk rebalancing means further comprises:

20 a free disk space measuring unit which measures the free disk spaces in the individual network storage devices;

 a rebalancing controller which determines the difference between the maximum value and minimum value of the free disk space in each of the individual network storage devices obtained
25 from said free disk space measuring unit, determines to start

rebalancing if the difference is equal to or greater than a first threshold,

selects a network storage device having the smallest free disk space as the source network storage device and a network storage device having the largest free disk space as the destination network storage device, and stops said rebalancing when the difference between the maximum value and minimum value of the free disk spaces falls below a second threshold; and a file object mover which moves files from the selected source network storage device to destination network storage device and thereby carries out said rebalancing.

20. The virtualized network storage system according to Claim 19, wherein said virtualizing device has a free disk space table and the free disk space table holds the identifier and free disk space in each of said multiple network storage devices.

21. The virtualized network storage system according to Claim 19, wherein

said file object mover moves files by: copying files in the source network storage device to said destination network storage device; deleting the files from the source network storage device, and updating said file location information, and

said virtualizing means comprises a means which operates in parallel with the file object mover and if a user sends a write access request into a file to be moved by the file object mover,

abandons the access request.

22. The virtualized network storage system according to Claim 19, wherein

the virtualizing device further comprises a management unit which receives instructions from an administrator and modifies the configuration of the virtualizing device according to said instructions, and

the management unit causes said rebalancing controller to determine start of rebalancing based on the difference between the maximum value and minimum value of the free disk spaces when receiving an instruction to start free disk space rebalancing from the administrator, and stops said rebalancing control means when receiving an instruction to terminate free disk space rebalancing from the administrator.

15 23. The virtualized network storage system according to Claim 19, wherein

the virtualizing device further comprises a counter which causes said rebalancing controller to determine start of rebalancing based on the difference between the maximum value and minimum value of the free disk spaces at preset time intervals.